§9. Poloidal Broadening of the Divertor Heat Flux Depending on the Radius of the Magnetic Axis

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The strike-point wetted area is quite important for determination of the heat flux flowing into the divertor plate. In an axisymmetric device such as a tokamak type, the wetted area can be simply calculated from a product of a width and a total length of the strike point along the torus. In a helical system, due to the difference of the rotation transform around divertor plates, the length of the strike point is usually longer than that of a comparable-size divertor tokamak. However, the width of the strike point is not uniform at different toroidal angles in helical devices; the divertor flux is located on particularly narrow areas.

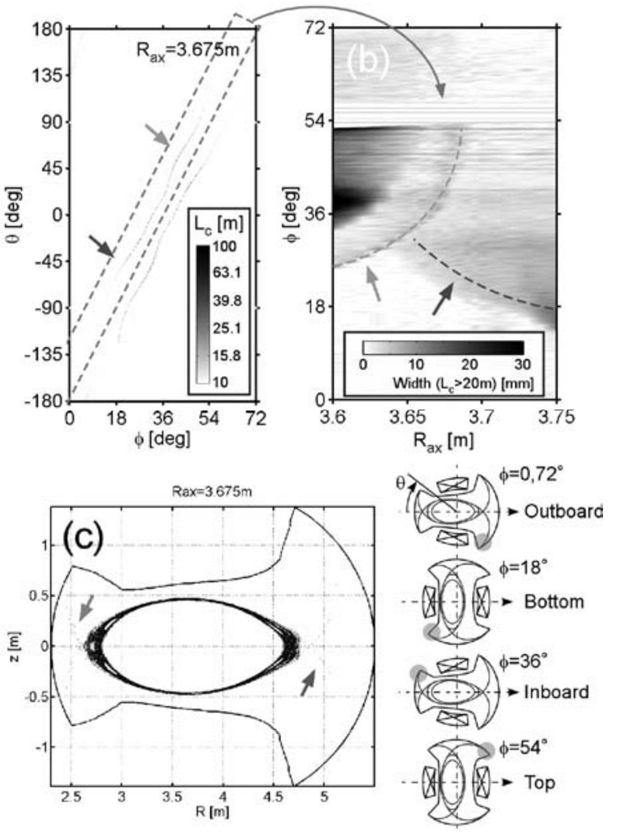

Fig. 1. (a) L_c distribution around the divertor plate for R_{ax} = 3.675 m, (b) width of the L_c > 20 m area, and (c) Poincaré plot of magnetic field lines on the horizontal-elongated cross-section for R_{ax} = 3.675m.

In the Large Helical Device (LHD), the divertor flux concentrates on the inboard-side divertor region in an inward shifted configuration of the magnetic axis position, R_{ax} ~ 3.6 m[1]. On the other hand, the deposition pattern moves to the upper and lower sides at R_{ax} ~ 3.75 m. The past study[2] indicated that there is a sudden change of the strike-point pattern at R_{ax} ~ 3.66–3.67 m. In this study, we have investigated the detailed relationship between the R_{ax} and the strike-point pattern from the magnetic field tracing; then, we confirmed the calculation result with the Steady-State Operation (SSO) experiments.

Firstly, we have calculated magnetic-field connection length (L_c) around the toroidally and poloidally rotating divertor plates at the minor radius of ~1.52 m for several R_{ax} cases. Figure 1 (a) shows a L_c distribution with two strike points at R_{ax} = 3.675 m as functions of the toroidal and the poloidal angles, ϕ and θ, respectively. From such figure, we estimated the width of long L_c area (L_c > 20 m) as a function of ϕ for R_{ax} = [3.6 m, 3.75 m], as shown in Fig. 1(b). It can be found that there are two typical patterns having curves elongated from the inward and outward shifted R_{ax} positions. These patterns are strongly related to the X-point positions that release the divertor flux. At R_{ax} ~ 3.675–3.68 m, there is no thick strike point (>~10 mm), but both the two patterns merges; length of the effective strike point along the torus becomes relatively long.

In the aim of decreasing a maximum temperature of divertor plates during a SSO discharge, broadening of the divertor flux in the poloidal direction is one of the valid procedures. To confirm the broadening effect, we measured temperatures inside the poloidally-distant divertor plates by thermocouples for R_{ax} = 3.65 and 3.675 m, as shown in Fig. 2. By comparing these two cases, we concluded that there was a certain effect (~10%) to reduce the maximum temperature.

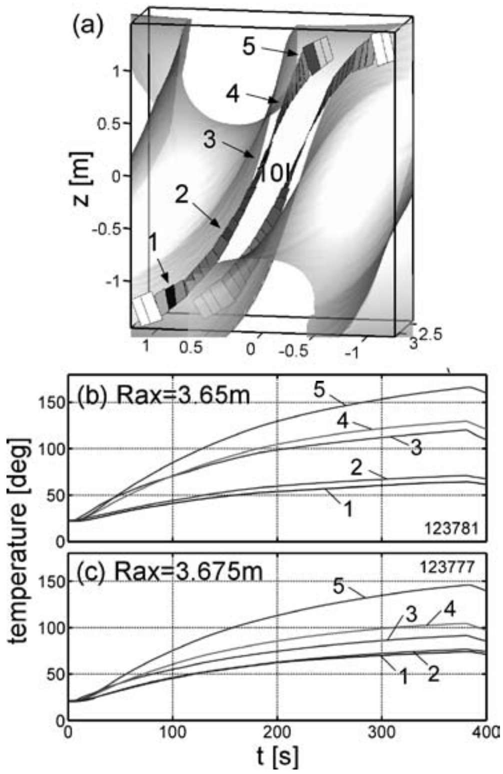

Fig. 2. (a) Divertor plates with a thermocouple. Time series of the divertor-plate temperatures during the same heating power shots for (b) R_{ax} = 3.65 m and (c) 3.675 m.

1) Morisaki, T. et al.: Contrib. Plasma Phys. **42** (2002) 321.
2) Ogawa, H. et al.: Plasma Fusion Res. **2** (2007) 043.